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Low-carbon governance in China – Case study of low carbon industry park pilot

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ABSTRACT

China is under the pressure of international climate change negotiation, domestic energy security and haze reduction. Replying to these pressures positively, China announced to reduce 40%–45% CO_2 per unit Gross Domestic Product (GDP) in 2020, 60%–65% CO_2 per unit GDP in 2030 based on 2005 level, and to carry out ambitious reduction measures. To achieve this target, low-carbon governance is necessary. The central government expects to build low-carbon society and develop low-carbon economy through pilots. This paper analyzes the framework of low-carbon governance in China. The government plays a guidance role in the governance process which involves enterprises, NGOs and citizens. Different types of measures, policy tools and actions have been implemented as response to the pressure. The governance can be achieved through the integration of technical, spatial and social pathways.

The paper analyzes the framework by using Suzhou Industry Park (SIP) as case study which is a very important part of low carbon management of cities. Although the total CO_2 amount in the Park has increased, its CO_2 intensity per unit GDP has been reduced in recent years after the efforts made by its Park Council and enterprisers. The policy implementation indicates that the guidance role of local governments and the process are still based on a top-down management at park level, although the National Development and Reform Commission (NDRC) hopes to carry out pilot program and summarize experiences from a bottom-up mechanism. Target Responsibility System (TRS) is still the key working mechanism and makes contribution to the reduction of CO_2 per unit GDP. The low-carbon governance experiences of SIP can be learned by other cities, while local government displays positive attitudes towards low-carbon practices.

1. Introduction

China is facing pressure from both international negotiation and domestic economy development. The advantage of lower per capita CO_2 emission has been gradually lost while negotiations following rapid increase of energy consumption. The country is still locked into traditional economic development model, with high material input and energy intensity, serious pollution and low profits. In addition, it will be one of the worst impacted countries by climate change, which could cause a serious economic loss. To combat climate change, China has positively taken different types of domestic low-carbon policies and actions. It announced to reduce 40%–45% CO_2 intensity per unit GDP until 2020, and 60%–65% until 2030 based on 2005 level. It also tries to control CO_2 peak around 2030 and increases renewable energy ratio into 20% until 2020. It aims to make transfer to low-carbon economy and society taking this opportunity. China has made efforts for low-carbon transformation through pilots. The National Development and Reform Commission (NDRC), representing the central government, selected 42 low-carbon city/provinces pilots (LCCPs/LCPPs) between 2010 and 2012. The number of low-carbon city/provinces pilots increase to 87 when the third batch has been announced. NDRC also announced 55 low-carbon industry pilots in 2014 as further demonstrations at different administration levels. (see Table 1)

Centered on the efforts to steer or guide human's action, the concept of governance has become popular in recent decades, and it has been used in different policy areas (i.e., energy and environment), highlighting the participation, interaction and coordination of different stakeholders. The horizontal (between departments, institutions or stakeholders in local and regional

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Table 1
Population and GDP in SIP, Jiangsu province and China.

Indicators	SIP	Jiangsu	China
Population (ten thousand)	71.46	7920	135,400
GDP (billion)	176	5400	51,932
GDP per capita (dollar)	43,157.4	10,888	6100

governments) and vertical relations (top-down or bottom-up control of local, national, and international policies) between different levels of governance have been included (Lo, 2014; Young, 2012).

In the past decades, several studies have been carried out to analyzing low-carbon, governance in different countries from different discipline (Young, 2012). Most research has focused on the role of the nation to the reduction target setting as well as policy implementation towards a low-carbon future from the technological, social and economic perspective, to be consistent with 2-degree target.

There are large number of case studies, analyzing low-carbon governance cases at local level about special topics in different cities (Aall et al., 2007; Allaire and Blanc, 2003; Breitmeier et al., 2006; Eversole and Scholfield, 2006; Helmut Breitmeier et al., 2011; Keskitalo, 2004; Kousky and Schneider, 2003; Lahsen, 2005; Mcleman, 2011; Norgaard, 2009; Pelling and Uitto, 2001; Tompkins and Adger, 2005; Wilbanks and Kates, 1999). There are some research on low-carbon cities in China (Baeumler et al., 2012; Dai, 2009; Khanna et al., 2014; Lo, 2014; Sperling and Ramaswami, 2013; Su et al., 2012; Yang and Li, 2013; Zhang et al., 2011; Zhu et al., 2015), but few of them are from governance perspective. Actually, there should be much further research on low-carbon governance in China, because in the future China would play a more important role on coping with climate change in the post-2020 period. In terms of low-carbon governance, mitigation and adaptation are the two key sides and most discussions are focusing on mitigation right now. The understanding of low-carbon working mechanism in China is significant, due to the coordination to the energy system, climate problem, economic growth presents important opportunities for future practice and better CO_2 reduction. The ultimate goal of the research is seeking to understand low-carbon governance framework in China, and to find out how it works based on current institution through case study.

In 2014, in order to promote the low-carbon transformation of the industrial park, the Ministry of Industry and Information Technology, the NDRC launched a national low-carbon park pilot policy, selecting the first batch of a total of 55 industrial parks become the low-carbon park pilots. The requirements for the creation of low-carbon park include: 1) Strengthen the low-carbon production design; 2) Promote the development of low-carbon technology research, development, application and industrialization; 3) Establish and improve the park carbon management system, prepare the carbon emissions inventory and construct the park carbon emissions information management platform; 4) Strengthen the construction of low-carbon infrastructure; 5) Carry out the international cooperation.

With the attention of the international and domestic government, some provinces that are heavily dependent on domestic coal are also seeking to produce some non-discharged electricity while supporting innovation and technology development. From this we can see a large number of state-level policies and planning has begun to implement into the provinces, municipalities and industrial parks. But at the same time, we also see the bottom-up policy is increasing. Of course, this work is also under the guidance of the state council. China sets overall performance targets and then allocates them to provinces and municipalities. Local governments in the central policy design under the guidance of a unified goal to achieve their policy design.

Suzhou Industry Park (SIP), located in Suzhou, is one of the second batch of national low-carbon city pilots (LCCPs) in Jiangsu province, eastern China. SIP is one of the national low-carbon park pilots (LCPPs) approved by the NDRC. By doing investigations in the park, this research analyzes low-carbon governance mechanism in China through using it as case study. Established in 1994, the park has an administrative area of 288 km^2, including 80 km^2 cooperation zone between Singapore and China (namely “core zone”). It shares 3.5% area of Suzhou, and at the end of 2013, it had a residential population of 771,000 people, sharing 5.8% people of the city and it plays a very important role of the economic development of Suzhou, contributing 15% of the city's GDP. In 2012, the proportion of the first industry, second industry and the third industry to the city's GDP was respectively 0.12%, 62.2% and 37.7% (GDP was 173.8 billion RMB). The major industry is manufacture industry, including electronic information, machinery and equipment, chemical raw materials and products, paper and paper products, medicine, food and other industries, accounting for about 60% of the park's GDP. In 2014, it has been one of the industry park pilot to strengthen the low-carbon production and reduce the carbon-dioxide emission.

This paper is structured as follows. Section 1 describes current research on low-carbon governance. In section 2, low-carbon governance framework in China would be analyzed. Section 3 presents the description of low-carbon governance in SIP as case study. The discussion on SIP low-carbon practical experiences would be carried out in Section 4. Finally, the conclusion brings a close in Section 5, where future outlook would also be suggested (see Fig. 1).

2. Framework of low-carbon governance

2.1. Pressure-response mechanism

The framework of low-carbon governance in China is summarized in Fig. 2. After reorganization of the pressure from the international community, domestic energy security, environment protection, the central government, local governments, and multiple participations, such as Non-governmental organization (NGO), and enterprises, response in different ways. The reply depends on the pressure and is directly proportion to it. The central

Fig. 1. The location of Suzhou in China.

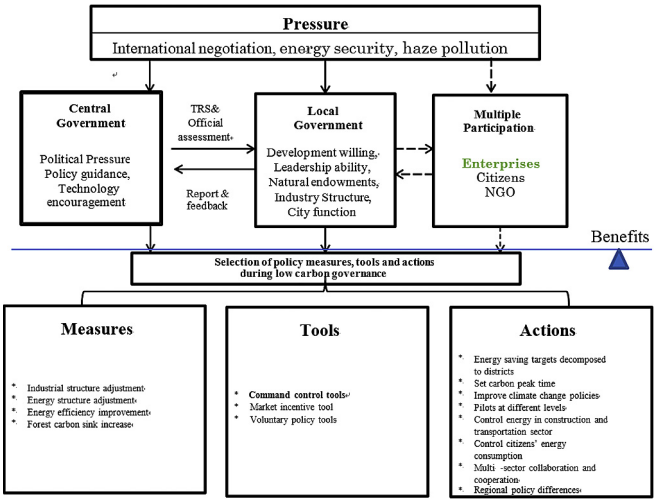

Fig. 2. Framework of low-carbon governance in China.

government has become very ambitious in coping with climate change recent years and published increasingly climate change policies (Wang et al., 2015a; Qi, 2009; Zheng et al., 2014) (see Fig. 3).

Current low-carbon governance in China is based on the target responsibility system (TRS). Low-carbon development targets, such as CO_2 reduction per unit GDP, renewable energy sharing ratio and CO_2 peak time etc. are decomposed from national level to city level and then to the country/enterprises level. Finally, these targets are assessed after policy implementation. Being a global and regional environmental issue, the goal and its achievement of low-carbon governance are based on balance of different participations, which is based on new climate economics theory (New Climate Economics, 2014). It is implemented considering two sides, which are the economic development and environmental protection.

The framework is based on the political hierarchy system in China. Received the supports from upper-level government, local governments can publish their own policies and carry out their own practice. Supports from higher level governments are very important for local governments. On the one hand, they can have increasingly subsidies or funds; on the other hand, good governance can help the promotion of local government officers. The participation of governments can improve the policy institutions establishment, which is of importance due to the unsound market mechanism.

Current working mechanism of low carbon governance in China is regarded as a bottom-up model (Wang et al., 2015b). However, based on our recent investigation, we made some update. The central government gives certain discretion to local governments. For example, they can carry out low-carbon actions in different sectors, setting low-carbon development targets. The bottom-up working model of the governance is still based on a top-down control under TRS, which was used successfully in the 11th Five Year Plan (FYP). In other word, the working mechanism of the low-carbon governance at city level is still top-down, which means that the targets set by the city government is decomposed to its counties, departments or industry enterprises.

The implementation of governance is guided by the government, and both the central government and local governments take different types of measures and actions using various kinds of policy tools. The benefits of different stakeholders are kind of balance.

2.2. Participations

Good governance is the driver of the city's sustainable development. Different participations, such as governments, enterprises, citizens and NGOs involve in low-carbon governance process. They are balanced by different cooperation and co-benefits. Benefits of different participations are the basis of governance. Urban

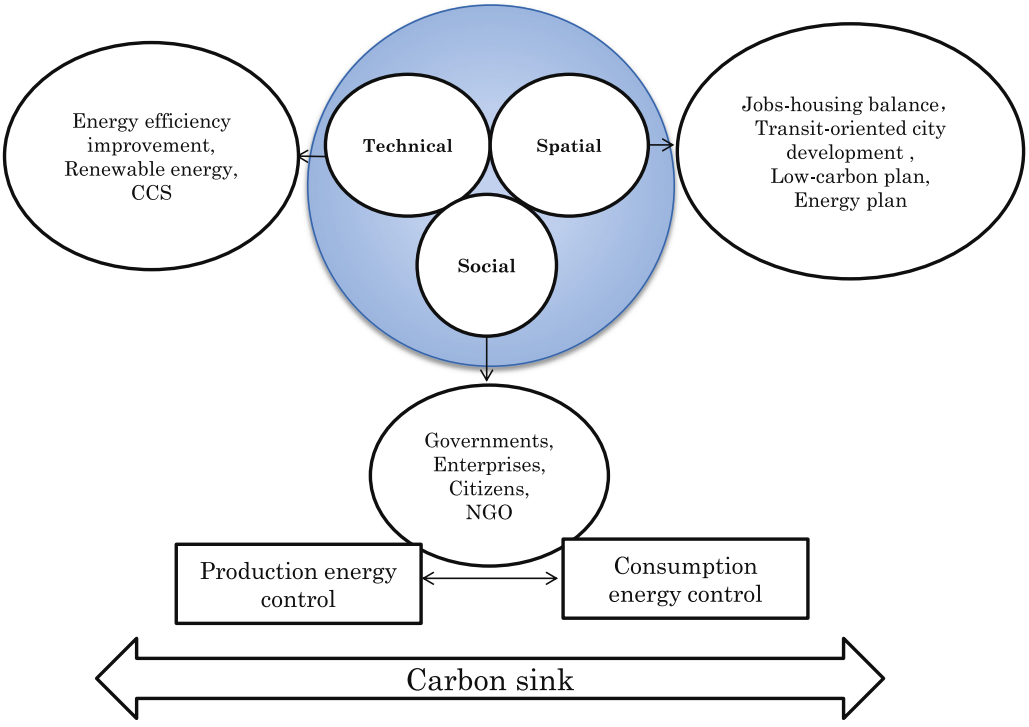

Fig. 3. Low-carbon development pathways.

governance is the driving force for sustainable urban development, the city's different participations involve in the urban low-carbon governance. Between them, there is a mutual benefit in cooperation and interaction. Low-carbon governance is different from the traditional environmental protection, because low-carbon governance is not only related to the energy system. As crucial product material, energy is affected by market. The traditional environmental protection, such as soil pollutant, and water pollutant, is a kind of public good. The city government should undertake the role of environmental protection to guide other participations for citizens' good living condition. However, the low-carbon governance is as an important mean of product, affected by both market and non-market factors. Excepted for the government guidance, enterprises have the wills to participate actively aiming to reduce product cost and save resources considering their own benefits.

(1) Government guidance to local government

Both the central and local governments play a guidance role to lead the low-carbon governance process. The central government is the key participation, and the local governments (including the provincial government and city government) have the requirements for sustainable development. The performance is the benefits of games. The central government treats cities differently because they are from different regions and in different development stages. Different cities, considering their own administrative hierarchy, city size, agglomeration economy etc., carry out their own appropriate control measures. They gradually decentralize to enterprises, allowing them to obtain certain rights of the public goods and services, namely benefits.

(2) Enterprise's Feedback

State owned-enterprises, especially those from industry sectors, are important players, because in China's current energy system, industry remains an important consumer of energy. In the "11th FYP" and "12th FYP", 1000 enterprises and 10,000 enterprises took part into the national energy saving program. Their participation is impacted by their size, industry, and ownership etc. (Zhao and Wu, 2016).

Private enterprises belonging to energy or energy-intensive industries, cannot be ignored. According to our investigation, it seems that most of them do not care about their climate performance. It is a bit hard for them to take part into mitigation actions without enough government encourages. What they care more are benefits but not social responsibilities. It is really difficult to manage so many small-scale rural industries, which are main contributions to local financial incomes.

(3) Citizens

Energy consumption of citizens has always occupied a dominant position among the energy consumption of the country. The sharing ratio of construction and transportation sectors will gradually increase in the future, and energy demands in these two sector is particularly worthy of attention.

It is indicated that while combing climate change, individuals and communities are regarded as important participations. Their response abilities of climate change are determined by the location of their settlements, by how those settlements are serviced, how effective their local government manages. Of course, different individuals always hold different capacities of coping with climate changes, due to their different education background, personality characters etc. Their lifestyles and consumption patterns will influence energy conservation and emission reduction. They are encouraged to buy environmental friendly products and lead low-carbon lifestyles by using public transportation, plant voluntarily and other actions.

(4) NGO

NGOs, as a main force of Chinese civil society, function as the bridge between public society and governments. Right now, many international environmental NGOs, such as the World Resources Institute (WRI) and Greenpeace have offices in China. Previously, they played roles in increasing public awareness of environment protection, such as water contamination and food security. However, there is not too much concern on climate change issues. Recent years, they have made more efforts on coping with climate change. They conduce to the increase of public consciousness and then enhance climate change management. They also play a role to pressure Chinese government from international communities.

2.3. Policy tools

Policies tools, generally implemented in the form of technologies by governments, measures and actions for their development goals. They can be divided into command-control tools, market-incentive tools and voluntary tools. Command-control tools, such as energy saving standards in construction sector and ban of non-coal use area are the most important policies applied by LCCPs. This mainly stems from current political system in China, and actually good performance, especially on energy saving in the 11th FYP(Qi and Huimin, 2012). The policies are flexible when assign targets and tasks. Market-incentive tools refer to fiscal, taxation and subsidies implemented which can be adjusted through market mechanisms. In China, specific funds in energy saving has successfully implemented and carbon trade are pending further developments. Voluntary tools are generally carried out by enterprises and public. Generally, the tool's application is supposed to follow some principles, such as free idea changing, mutual benefit coordination, effective consultative mechanism, multiple participation, good incentives and monitoring.

2.4. Pathway

Mitigation and adaptation have become the key goal of low-carbon governance, and mitigation is the focus of the government. It requires the efforts of different participation. It refers to the pluralistic governance at different scales and sectors, and it should be achieved through different pathways. It should be the integration of technology, spatial and social dimensions. It is the combination of global environmental governance and regional environmental governance at urban level. In particular, at the technical level, it includes energy saving technologies, renewable energy technology and carbon capture and storage (CCS). At the spatial level, it is related to the urban planning. From the side of social pathway, it involves the participation of governments, enterprise, citizens and NGOs. From the view of the entire energy system, efforts of energy saving should be carried out from both the production and consumption side. From the environmental protection perspective, low-carbon development has co-benefits of CO_2 reduction and haze reduction. Each pathway can impact the others. It is connected with the whole social and economic systems, and it also has relations with a single family or individual. During policy implementation, all pathways should be considered systematically.

3. Case study of SIP

The energy management and low carbon governance experiences of SIP will be introduced in this section as a case study. The industry park is a very important part of the city, generally contributing mostly to the city's economic growth. We used data from 2005 to 2015 and analyzed the responding policies, aiming to find out the policy impacts on CO_2 reduction and figure out the governance process.

3.1. Energy consumption and CO_2 emissions

(1) Total energy consumption and CO_2 emissions

The total amount energy consumption of SIP increases from 2.2 million tce in 2005 to 4.7 million tce in 2012. And its GDP grew rapidly during this period, while its energy intensity per unit 10,000 RMB GDP reduced gradually (shown in Fig. 4). Most energy consumed of SIP comes from the electricity transferred outside of the city.

Its CO_2 emission increases from 4.4 million tons in 2005 to 10.8 million tons in 2012, with an annual increasing ratio of 13.6% (shown in Fig. 5).

In terms of CO_2 intensity per unit GDP, it has an overall downward trend from 2005 to 2012, and in the year 2010, its economy development and carbon intensity has been decoupling (shown in Fig. 6)

(2) Energy consumption and CO_2 emission in different sector

Proportion of the third industry constantly has been adjusted. Share of agriculture and industry is gradually reduced, and the proportion of the service sector is rising. The CO_2 intensity of industrial sectors declined with fluctuation from 2005 to 2012, while the services sector declined significantly from 2010 (as shown in Fig. 7). In 2012, CO_2 from industry sector, service sector, citizen's life & transportation sector, and agriculture sector & waste disposal process accounted for 76%, 11%, 6% and 1%, respectively (see Fig. 8).

Due to the increase of economy development and the citizen living level, CO2 emission per capital increases gradually. In 2012, its level is higher and the national average level has caught the levels of some EU countries. The main reason is that the energy consumption in transportation and construction sector has been increased.

3.2. Institution and policies

(1) Institution structure

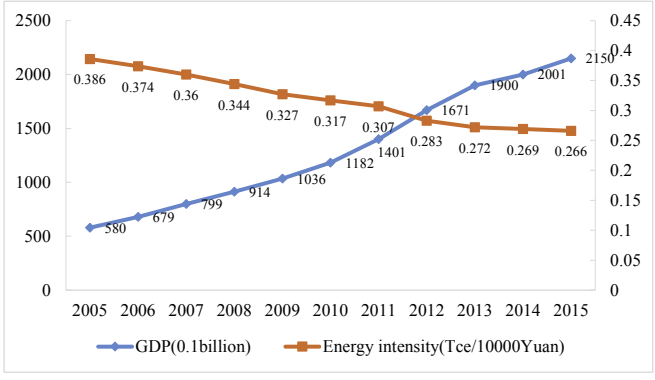

Fig. 4. Energy intensity and GDP from 2005 to 2015.

As a national-level industrial park, SIP set up a Park Council, responsible for the administrations work between China and Singapore. The Park Council has Trade &Economy Development and other relevant bureaus (Shown in Fig. 9).

In order to adjust the national organizations, the SPI established several working groups related with energy conservation, energy efficiency and emission reduction, circular economy pilot and energy conservation in construction. Most of them are based on the institution in SPI.

(2) Policies

The park has issued the "12th FYP of SIP", the "Energy Saving Action Plan in 2013", the "Ecological Optimization Action Plan of 'key project'", the "Accelerating the construction of ecological civilization of SIP" and other local policy documents in recent years (see Table 2). SIP takes awareness of drawing up the urban plan. For example, on the basis of the 1994 city plan, SIP is preparing the following programme, the "Ecological Optimization Plan (2010–2020)", the "Ecological Civilization Plan (2010–2020)", the "Energy plan", the "Low-carbon Development Plan", the "Circular Economy Development Program", the "Energy plan in Construction sector", the "Water Resource Comprehensive Utilization Plan" and the "Green Transportation Plan". Excepted for the policies published by the Park itself, it also follows those policies of Jiangsu Province and Suzhou City, which are shown in Table 3.

3.3. Policy implementation

3.3.1. Reduction targets

SIP sets up a series of low-carbon development or energy saving targets higher than the national average level. It aims to control CO_2 emission reaching to the peak during 2019–2020 at the amount of 13.2 million tons after a small fluctuation between 2020 and 2025, and then decline steadily. It is expected to reduce 16% in 2015 and 26% in 2020 of the energy intensity per unit GDP based on 2010 level. The national target is to reach CO_2 peak time around 2030. The energy intensity per unit GDP is required to reduce 16% in 2015, and 25% in 2020 based on 2010 level. The CO_2 intensity will reduce 10% in 2015 based on 2010 level, 21% in 2020 based on 2005 level, and in 2020 will reduce 28% based on 28% on 2010 level, and 38% on 2005 level. CO_2 intensity per unit GDP should reach to the peak at 15.2 tons/person in 2017.

3.3.2. Policy evaluation indicators

In order to push and assess the policy implementation, SIP set two types of targets, binding and non-binding targets (Shown in Table 4). The Energy intensity &carbon intensity, and total CO_2 amount are binding. Other indicators are non-binding (see Table 5).

3.3.3. Measures and actions

3.3.3.1. Plans. The park pays attention to city plans (park planning) following the principle that "industry firstly, the infrastructure and then residential and commercial function secondly". It has an indicator of land using, which is investment intensity per square kilometer ($\geq$\$ 5500 million/km^2 in the China-Singapore core area, $\geq$ \$ 3400 million/km^2 in other area). Jobs-housing balance has been considered based on the Singapore's experiences.(see Table 6)

3.3.3.2. Policy implementation. Sector structure adjustment, energy structure adjustment, and consumption style adjustment are the most important CO_2 mitigation measures, which accounting for around 70%, 8% and 7.5% of the CO_2 mitigation measures, respectively.

In its industry enterprises, low-carbon technologies are applied

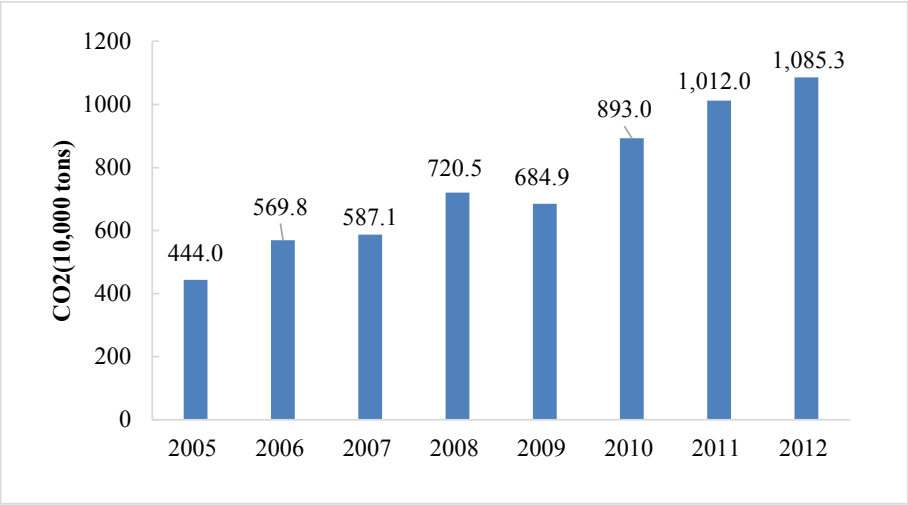

Fig. 5. Total CO_2 emission from 2005 to 2012.

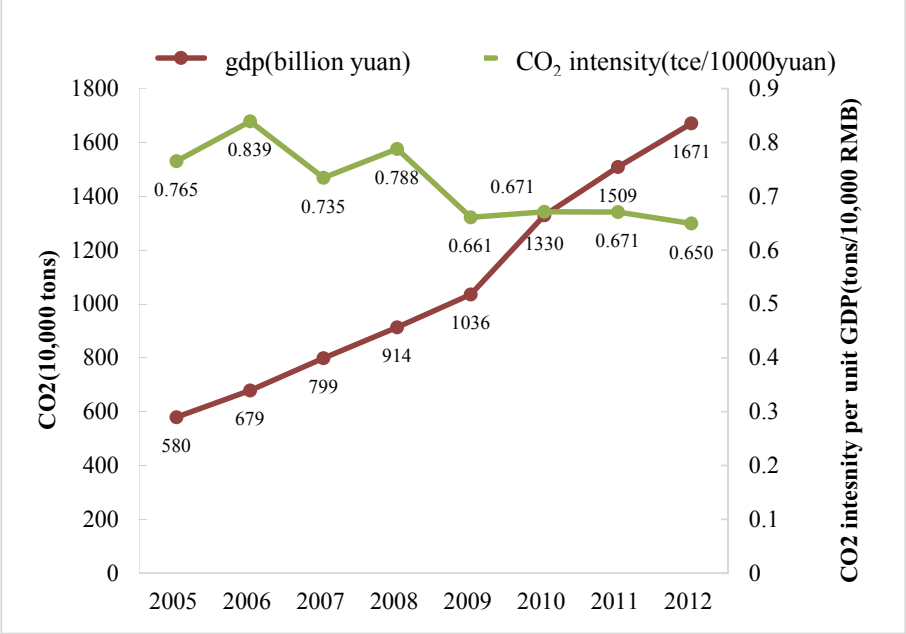

Fig. 6. Carbon intensity and GDP from 2005 to 2012.

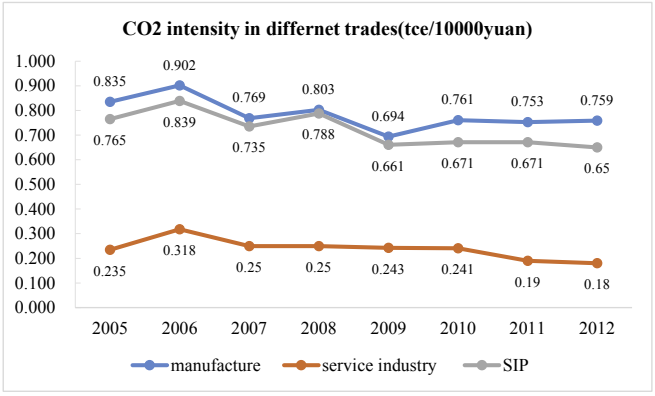

Fig. 7. Carbon intensity of output in different trades from 2005 to 2012.

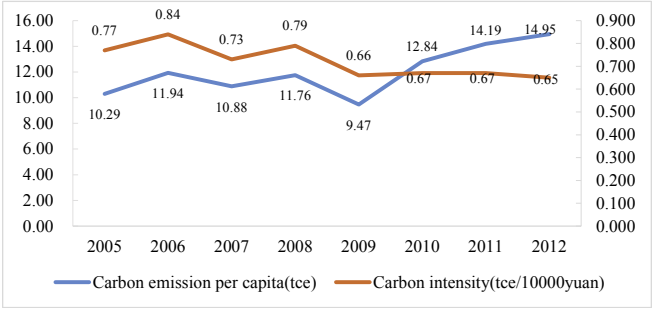

Fig. 8. CO_2 intensity per capita and carbon intensity per capita from 2005 to 2012.

widely, including Combined Cooling Heating & Power (CCHP), Distributed Photovoltaic (DPV), smart grid, demand-side power

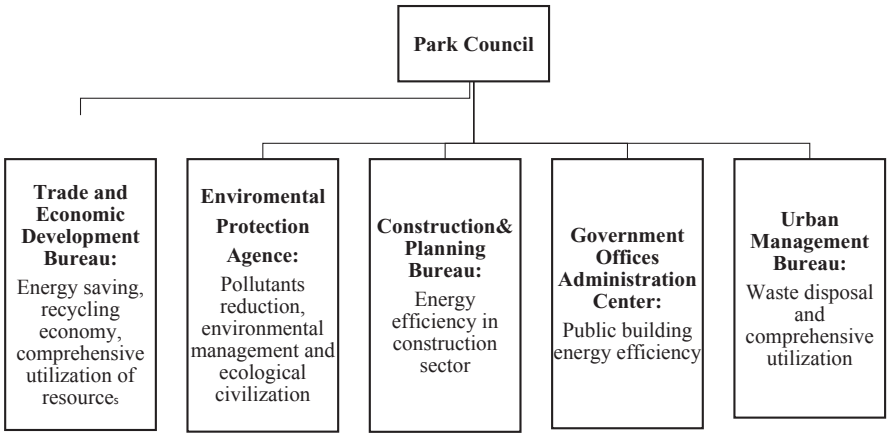

Fig. 9. Institution structure of SPI.

Table 2
Energy consumption in different sectors of SIP (10,000 tce).

Sector		Year				
		2005	2006	2010	2011	2012
Agriculture		0.07	0.06	0.03	0.01	0.02
Industry		190.61	210.88	284.16	328.76	350.85
Transportation		8.88	11.68	20.80	31.22	32.45
Construction	Service	13.71	19.00	43.11	46.79	53.66
	Citizen	10.89	12.53	26.59	26.33	30.82

management system and centralized heating and cooling projects. It also carries out carbon inventory assessment of the plants and carbon footprint of products by applying life cycle assessment in electronic enterprises in core area.

Till 2013, there have been around 70 buildings with green certificate, which are more than 7 million square meters, accounting for half of the whole province. To 2015 and 2020, the sharing ratio of new green building is required to be 80% and 100%, respectively.

Transportation Department set a series of reduction targets, too. For example, it aims to install 50% smart bus stations in 2015 and 100% in 2020. It also tries to increase public transportation sharing ratio into 80%. The hybrid buses will be used to replace previous buses. The bicycle renting system will be applied much widely to improve its convenience. “Energy efficiency star” has been implemented among service sector, especially in hotels and restaurants, which will receive subsidies, tax duty or other financial assistance from the government.

Green energy consumption is encouraged and lot of programs have been carried out, such as “Second-hand market” and “No-car driving day”. Garbage classification improves its recycle and reuse.

Table 3
Major climate change policies in Suzhou and Jiangsu.

Program	Region	
	Suzhou	Jiangsu
Energy Conservation	Notice on the “Top 1000 enterprises energy saving Program” Notice on “Top 100 enterprises energy saving program” Further promotion of the energy audit in city's key energy-consuming enterprise Notice of energy saving incentives in Suzhou New energy vehicles subsidies (2015) Old car recycling subsidies (2015) Energy conservation and emissions reduction low-carbon development action plan (2015) Implementation of contract energy management (2014) Energy management system requirements (2014)	Energy conservation for public sectors, Jiangsu Energy-saving emission reduction low-carbon development action implementation plan (2014–2015) Development the low-energy and low-emission industries Implementation measures of part of the production capacity of serious excess industry capacity replacement Measures for the Administration of Energy Saving Transactions in Jiangsu Province (for Trial Implementation) (2015)
Environmental protection eco-economy development	Guidance on the “Accelerating the circular economy development” Notice of the “Ecological Urban Construction Plan Suzhou” Suzhou high pollution fuel boiler atmospheric pollution treatment and implementation plan (2014) Low-carbon City Pilot (2012) Low-carbon Industrial Park Pilot (2014) Develop the Suzhou City Energy Management Digital Map System	Circular economy pilot program, Jiangsu Build energy saving emission reduction and carbon reduction projects Increase the reduction of motor vehicles Jiangsu Province Energy Conservation Regulations (2015) Regulations on the Development of Green Buildings in Jiangsu Province (2015)
Plan	Opinions on industrial restructuring, Suzhou Opinions on the speed up industrialization, Suzhou Prepare the carbon emissions list Establish the leader group of low-carbon city pilot eliminate backward production capacity, improve the ecological environment action plan in the last three years (2014) Implementation Plan of Air Pollution Control for High Polluted Fuel Boiler in Suzhou City (2015)	Guidance on “Catalogue of Industrial Structure Adjustment, Jiangsu” Plan on controlling the total energy consumption program of work (2014) Jiangsu Province, "thirteen five" energy - saving plan (2016) Jiangsu Province, coal-fired energy-saving emission reduction upgrade and transformation action plan (2014–2020)

Table 4
Policy evaluation indicators.

Indicators	Sub-indicators	Unit	Targets	
			2015	2020
Energy intensity &carbon intensity	Energy consumption per unit GDP	tce/10,000 ton	0.266	0.234
	CO_2 per unit GDP	t/10,000 ton	0.537	0.420
CO_2 amount	Total CO_2 amount	10,000 tons	1200	1320
Low-carbon development	Sharing ratio of service sector	%	44	60
	Industry CO_2 sharing ratio to CO_2 of the country	%	65	60
	CO_2 per unit output	t/RMB	0.664	0.600
Energy saving in industry sector	Number of key enterprises with the clean production auditing	number	80	120
	Number of key enterprises with good energy audits	number	150	250
	Proportion of clean energy	%	85	90
In for technology	Number of electric information enterprises with carbon inventory in core area	number	18	36
industry	Number of electric information enterprises with energy conservation in downtown	number	5	15
Low-carbon in non-industry	Sharing ratio of green buildings in new building	%	90	100
	Urban public transportation share ratio in downtown	%	50	65
	CO_2 per capita	tce/person	13.2	13.5
	The number of garbage classification community pilots	number	12	15
	Sharing ratio of low-carbon communities	%	80	95
Increase carbon sink	Built-up green area coverage	%	45.8	45.8
	Forest coverage	%	≥25	≥25
	Public green area/capita	m2/person	45	55
Increase the low-carbon development	Carbon monitoring, statistics &monitoring system	Yes/no	Application	Improvement
	Low-carbon assessment mechanism	Yes/no	Application	Improvement

Table 5
The contents of different low-carbon pilots.

Pilot	Contents
low-carbon industry park pilot	1 Improve the production process of key energy-consuming enterprises and encourage enterprises to invest more in energy conservation and emission reduction projects
	2 Build a new low-carbon economy statistical library, environment and safety monitoring and management platform to achieve the goal of intellectualization of low-carbon management in the park
	3 Mobilize key enterprises in the park to play a leading role, enhance the awareness of low carbon production in enterprises, and gradually implement the national energy and carbon emission management system
low-carbon green-ecological pilot	1 Develop low-carbon city planning
	2 Construct low-carbon infrastructure, energy-efficient buildings and green buildings, green transport systems, and ecological green space systems
	3 Establish a renewable energy utilization system
low-carbon community pilot	1 Introduce new models of low-carbon property management and services, and promote energy-efficient buildings and green buildings
	2 Build efficient and low-carbon infrastructure
	3 Develop public transport and slow transportation facilities in the community, and vigorously develop low-carbon public transport.
	4 Strengthen the construction of supporting facilities for low carbon living in communities, plan and build public recycle rental and charging facilities for electric vehicles, and encourage the development of public e-bike rental in the community
	5 Strengthen the planning and design of ecological environment in the community and make full use of the noise reduction and noise reduction of green belts to build public green spaces and walking green roads that meet the needs of residents

Table 6
Different function of different departments.

Departments	Goals
NDRC	Set overall goals for reducing CO_2 emissions
Construction Department	Energy conservation reform of buildings
Transportation Department	Reduce carbon emissions from vehicle in transportation sector
Ministry of Environmental Protection	Monitor major pollutants
Environmental and Health Bureau	Waste management in cities
Agriculture Bureau	Construct environment-friendly and ecological agriculture

Until 2015, 95% communities are expected to be low-carbon community and the targets will increase into 100% in 2020.

The park also hopes to increase carbon sink through green balcony and walls. The covering ratio of green area in the built-area has reached into 46% and been satisfied with the requirements of the “Low-carbon economy development plan of SIP”.

3.3.3.3. Policy tools. Different types of policy tools have been implemented, such as command-control tools and market-incentive tools. Except for closing outdated production, in order to adjust energy structure, the park carried out “Oil to Gas” projects and set “No coal burning area”. Suzhou city has established low-carbon development funds, and to 2014, SIP has 70 million RMB for environment protection, 15 million RMB for energy saving, and 4 million RMB for green construction.

The park also has policy innovation. It has established many system, including GHG data management system, and carbon assessment system, carbon reporting system, carbon reduction

performance assessment system, climate change adaptation mechanism, carbon information disclosure system and decision making-feedback system.

The policy is carried out through TRS system, and reduction targets set by the Park Council are decomposed into departments or enterprises. Expected for TRS, the carbon reduction has been combined with the government officer's performance assessment system, increasing the participation of different departments by rewarding and punishment mechanisms.

4. Discussion

Based on the investigation to SIP and other departments in Suzhou city, we analyze current policy implementation problems, and discuss the measures to improve it. The most contribution of low-carbon policy to the local government is to help the council to integrate the low-carbon work/energy saving work from different sectors together. However, the real contribution to CO_2 reduction or energy efficiency is limited.

Firstly, Coal is the dominated energy of Suzhou, taking 50 percent overall. It is not easy for the city to increase the proportion of renewable energy. SPI wishes to do energy cascade application and energy internet, but it is not easy to find out proper policy tools to apply on the two programs and promote them. Most enterprises in SIP are belonging to industry sectors, and they generate large amounts of GHGs. They have the international advanced technology level, and the CO_2 reduction potential by low-carbon technologies is limited. They try to do some work considering energy management. However, the park council set 16 million RMB to encourage low carbon work, but it is not enough. Both local governments and enterprises wish to have support policies from the country to help the enterprises recognize the importance of CO_2 management.

Secondly, excepted for low-carbon industry park pilot, SPI was selected as the low-carbon green-ecological pilot and low-carbon community pilot. It indicates that one assignment can be reported to different departments. Different departments can work together under the guidance of the Park Council. The communication between different departments becomes necessary. As a national industry park, it is much easier to receive funds and policies from the country and province. Different with other industry parks, the population, city area, and urbanization ratio in SPI is similar as some cities in advanced countries. Excepted for industry, citizens' energy consumption increases greatly, and more efforts should be made in low-carbon communities. However, they feel that according to the requirements of the low-carbon community policy announced by the NDRC, it is very difficult to carry out the detailed work at community. One reason is that the NDRC published the policy for the whole country, and rather than a single community, which is suggested to be amended in the future.

Thirdly, low-carbon governance involves the participation of different government departments. In China, energy management is controlled by the NDRC, and energy conservation in buildings is managed by the Construction Department. Low-carbon transportation pilot is leaded by the Transportation Department and the waste management is controlled by the Environmental and Health Bureau. At the level of the central government, each department announces its low-carbon pilot program. Those targets and policies are under the TRS mechanism and it should be adjusted when it comes to the local level and be coordinated by the Park Council. Policy implementation actually involves the allocation of rights in different sectors. Although industry enterprisers' attitude towards low-carbon development has started to change from negative to positive, their energy data are not good enough for carbon inventory calculation. The carbon reduction targets at the national and local level had better to be adjusted because the calculation methodologies are different. It should make clear that the relations between total reduction amount and low-carbon special plans in each sector. More researches should be carried out to find how to combine the reduction effects of the park into the city's routine work.

Fourthly, the SIP really takes awareness of climate protection more than other parks or cities, and it expects to know current low-carbon governance experiences of industry countries like the EU and Japan, low-carbon experiences from other LCCPs in China. Actually, right now, the governance lacks an independent agency for policy analysis and evaluation (policy making and policy evaluation should not be carried out by the same institution/department). Good governance should involve the participation of different stakeholders at both national and local levels vertically and horizontally. It is a mix of policies in different sectors. In the future, China will be deeply impacted by climate policies, and the announced targets, such like the CO_2 peak time, renewable energy sharing ratio will impact the policy making and implementation. Based on current development trend, in the future, the government will make more efforts on renewable energy application in China: PV used on roof and electric vehicle application at large scale. In the next ten years, increasingly policies in eco-civilization/eco-progress package[1] are expected be implemented with the aim for the sustainable society. However, both the central and local governments had better to do more researches and design the policies systematically.

5. Conclusion

China is at a crossroad on a sustainable development path, and its economy is in the new stage with a lower GDP growth rate compared with the past 30 years (from 1978 to 2014, annual GDP growth rate is around 10%, and the growth rate in 2015 is 6.9%). It has recognized the necessity and importance of climate protection as it faces the pressure of international negotiation, energy security and environmental degradation. However, the country has already commanded long-term and short-time commitment of CO_2 reduction and both the central government and local governments have positive attitudes towards climate protection.

This paper discusses current framework of low-carbon governance in China and policy implementation by applying SIP as case study. During this process, low-carbon industry park is able to be a major tool in the development of low-carbon city. Recently, energy consumption and CO_2 emissions have been increased greatly due to its fast industrialization and urbanization. However, energy intensity per unit GDP and the CO_2 intensity per unit GDP have been reduced. The central government started the governance from pilot policy announced by the NDRC, and wishes to share the experiences through bottom-up pilot. At the city level, it is a kind of top-down mechanism based on TRS, showing that the reduction targets are assigned to departments or key enterprises. Different types of policy tools, like command-control tools, market-incentive tools have been carried out as reply. Low-carbon city governance should combine the technology, spatial and social sides. During the policy implementation, communication is necessary among different departments and stakeholders and regional differences should be considered. It can be expected as the Chinese government plays a more important role in the international society after 2020. Currently, the government is looking for new drivers of the

[1] Low-carbon development is a significant part of the ecologic civilization. And in 2015, Chairman Xi has suggested the five developed methods, which include the green-developed method.

economics. Low-carbon economy development is a very good opportunity for sustainability and the concept of low-carbon is expected to play an increasingly role in the future.

Abbreviations

GDP	Gross Domestic Product
NGO	non-governmental organization
SIP	Suzhou Industry Park
NDRC	National Development and Reform Commission
TRS	Target responsibility system
LCCPs/LCPPs	Low-carbon city/provinces Pilot
FYP	Five Year Plan
WRI	World Resources Institute
CCS	carbon capture and storage
CCHP	Combined Cooling Heating& Power
DPV	Distributed Photovoltaic

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